CALIFORNIA MARINE LIFE PROTECTION ACT INITIATIVE

FINAL DRAFT ADAPTIVE MANAGEMENT AND MONITORING AND EVALUATION FRAMEWORK

March 7, 2006

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Executive Summary

The MLPA requires adaptive management to ensure that a system of MPAs meets its stated goals [Section 2853 (c) (3)]. The MLPA defines adaptive management as "a management policy that seeks to improve management of biological resources, particularly in areas of scientific uncertainty, by viewing program actions as tools for learning. Actions shall be designed so that, even if they fail, they will provide useful information for future actions, and monitoring and evaluation shall be emphasized so that the interaction of different elements within marine systems may be better understood" (Section 2852 (a)). Adaptive management requires learning from current experience to improve the process of achieving the goals of the MLPA over time. The law embeds ecosystem-based adaptive management, monitoring, and evaluation into the state policies related to the management of MPAs.

This approach will require the State to develop and implement a monitoring, evaluation, and adaptive management program. The MLPA Master Plan Framework (MPF) adopted by the California Fish and Game Commission (FGC) on August 18, 2005 describes the Monitoring and Evaluation for the MPAs. The AM&MEF compliments and expands upon the framework proposed by the MPF in two ways. First, it provides guidance on the institutions and processes for adaptive management which are not discussed in the MPF. Second, while the MPF discussion focuses on monitoring for evaluating the extent to which individual MPAs are accomplishing adopted goals and objectives (CDFG, 2005: pages 69-75) The AM&MEF describes an administrative approach at the regional scale. In it, adaptive management, monitoring, and evaluation will be implemented at multiple spatial scales, including individual MPA, MPA networks in a region, and statewide when appropriate. The Monitoring and Evaluation section of MPF should be revised in the future to reflect this change.

This document presents and recommends a framework and process for the adaptive management and monitoring and evaluation of MPA arrays for the entire State of California. An important part of marine ecosystem management, and incorporated in this framework, is the establishment of programs to monitor, evaluate performance, and adaptively manage the biological, social, and economic status and trends of areas within and nearby the MPAs. Long-term monitoring data are critical for understanding the status and trends of resources and identifying emerging threats to MPAs. The data will help managers, policymakers, scientists, and stakeholders determine the impacts and effectiveness of the MPA array. Data will be used to evaluate the progress towards achieving the statewide goals, regional goals and objectives, and objectives for individual MPAs established by the MLPA and by the regional stakeholder groups. They will aid in understanding the structure and function of ecosystems within the MPA system, and thereby provide an improved scientific basis for future decision-making. These data will be used for adaptive management of the MPAs. Finally, the AM&MEF will also provide guidance on how to implement the AM&MEF.

A sequence of decisions is required to address adaptive management and monitoring and evaluation requirements of the Marine Life Protection Act (MLPA). Key decisions and recommendations for each are listed below by section of the document. Expanded discussion of each item is available in the framework document that follows:

Section 1*, Overview: Marine Life Protection Act Statewide Framework for Adaptive Management and Monitoring & Evaluation,* will provide a discussion on the requirements of the MLPA, purpose of the framework, and adaptive management and monitoring in the MLPA.

Section 2, *MLPA Adaptive Management Process*, will lay out the process, roles of institutions for adaptive management. The following key decisions are discussed in this section:

- Decision 1. Choose the geographical scale for adaptive management and specifically the number of regions, somewhere between two and four.

  Recommendation: Align the biogeographical regions for MLPA adaptive management with the Nearshore Fishery Management Plan regions.

- Decision 2. Designate the bodies which will recommend changes in MPAs required for adaptive management (changes recommended to the California Department of Fish and Game (DFG) which recommends to FGC, the formal policymaker).

  Recommendation: Create a new consolidated Committee that combines the adaptive management functions related to the MLPA and those of the Nearshore Advisory Committees. A separate committee will be formed for each biogeographic region.

- Decision 3. Constitute the membership of the Regional MPA Management Advisory Committees.

  Recommendation: Named by the DFG Director; consisting of stakeholders and scientists who are knowledgeable about the key issues related to MLPA implementation.

Section 3, *Statewide Oversight and Management for Implementation of the AM&MEF,* will discuss the resources necessary to implement the AM&MEF, process for implementation, and issues for consideration. The following key decisions are discussed in this section:

- Decision 4. Develop the science questions that can inform adaptive management of networks of MPAs and those which can inform management of individual MPAs.

  Recommendation: These questions must support policymakers, address the concerns of key stakeholders, and be grounded by science. Many will derive from the rationale for adopting MPA networks or components of networks, the quality of the information on which the designation was based, and the network's, (or components of the network), stated goals. Similarly, many other questions will be suggested by the stated objectives of individual MPAs. Questions directed at individual MPAs are likely to be more easily developed and answered. Priority must be given to developing and addressing questions relevant to adaptive management of ecosystems, at scales ranging from individual MPAs to the biogeographic region. The set of questions selected must address this multi-scalar aspect of MLPA and adequately support adaptive management of ecosystems, which is the primary thrust of the MLPA.

- Decision 5. Resources must be acquired and deployed to implement the monitoring and evaluation plan and to support the processes of adaptive management.

  Recommendation: Consistent with the Long Term Funding plan recommended by the Blue Ribbon Task Force (BRTF), the State of California should take the lead responsibility but actively seek to develop and to effectively manage partnerships with other governments, philanthropic institutions, research organizations, fishermen, and others.

- Decision 6. Develop the institutional capacity and processes and the technical infrastructure to develop protocols, collect, maintain, analyze, archive, and communicate monitoring and evaluation data over long periods of time. Over time, this capacity and infrastructure should, as needed, support the development of new monitoring modules and spin-off related research and development projects.

  Recommendation: A dedicated organization, (referred to as "the Institute"), should be created to perform this role, guided by the MPA Management Advisory Committees, but also closely linked to the management structures of the DFG which will develop data and analyses to support adaptive management of the state's MPA network and individual MPAs.

Section 4, *Guidance for Regional Implementation*, provides recommendations how each region, using the Central Coast Study Region as an illustrative example, should move forward with the implementation of the AM&MEF. The role of partner organizations is critical for implementation and long-term success of the program. The following key decision is discussed in this section:

- Decision 7. Regional Adaptive Management and Monitoring, Evaluation Plan (s) must be developed to address the questions posed by policymakers and support anticipated future decision-making.

  Recommendation: This draft plan should be developed initially by the Institute and then reviewed by the MPA Management Advisory Committees and either adopted or sent back to the Institute for revision as necessary.

1. Overview: Marine Life Protection Act Statewide Framework for Adaptive Management and Monitoring & Evaluation

The Marine Life Protection Act (MLPA) requires adaptive management, monitoring and evaluation to ensure that that an effective system of marine protected areas (MPAs) is created and maintained for decades to come. The goals of the MLPA (MLPA Section 2859, see Appendix 1 for a complete list) are to protect natural heritage, diversity and abundance of marine life, sustain marine populations, improve recreation, education and study opportunities, ensure MPAs function as a network, and, manage them effectively. Monitoring and evaluation are critical to determine whether these goals are being met over time and to inform adaptive management that will refine MPA design, management and policy.

This document outlines a suggested statewide Adaptive Management and Monitoring and Evaluation Framework (AM&MEF) for MPAs. It proposes and recommends a structure and process. It also provides guidance for the state and regions on how to implement monitoring, evaluation and adaptive management.

1A. Purpose of this Framework

This document presents and recommends a framework and process for the adaptive management and monitoring and evaluation of MPA networks for the entire State of California. An important part of marine ecosystem management[1] and incorporated in this framework is the establishment of programs to monitor, evaluate performance, and adaptively manage the biological, social, and economic status and trends of areas within and nearby the MPAs. Long-term monitoring data are critical for understanding the status and trends of resources and identifying emerging threats. Such data will help managers, policymakers, scientists, and stakeholders determine the impacts and effectiveness of the MPA array. It will also be used to evaluate the progress towards achieving goals and objectives for statewide, regional, and individual MPAs. Finally, these data will be used for adaptive management of the networks and MPAs.

The AM&MEF will also provide guidance on how to implement the AM&MEF. *The Monitoring and Evaluation Report,* which describes the detailed methods for monitoring and evaluation statewide, will be developed for the state. It will describe the monitoring design recommendations as well as outline the methods used to collect the data to create a uniformity of data methods, collection, and management. This will be developed at a later date, revised as needed, and be a living document. Each region should develop a plan that is a living document to implement the AM & MEF, *Regional Monitoring, Evaluation, and Adaptive*

[1] Ecosystem-based management is an integrated approach to management that considers the entire ecosystem, including humans. The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. Ecosystem-based management differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the cumulative impacts of different sectors. (Compass. 2005. Consensus statement on marine ecosystem-based management. www.compassonline.org)

Management Implementation Plan. For further discussion on the regional implementation plans, see Section 4 and an illustrative Table of Contents in Section 4C.

Six basic principles guide the AM&MEF. The framework should: 1) be useful to decision-makers, managers, scientists and stakeholders for improving MPA design and management; 2) be practical in use and cost; 3) include both scientific and stakeholder input; 4) be flexible for use at different sites and in varying conditions; 5) be holistic in its focus on both natural and human perspectives; and, 6) be transparent in process and decision-making to all stakeholders and the public (Master Plan Framework, Section 6; 69).

1B. MLPA Requirements for Adaptive Management and Monitoring and Evaluation

The MLPA requires adaptive management to ensure that a system of MPAs meets its stated goals [Section 2853 (c) (3)]. The law embeds ecosystem-based adaptive management, monitoring, and evaluation into the state policies and management of marine resources and MPAs. This approach will require the State to develop and implement a cutting-edge monitoring, evaluation, and adaptive management program. The MLPA defines adaptive management as "a management policy that seeks to improve management of biological resources, particularly in areas of scientific uncertainty, by viewing program actions as tools for learning. Actions shall be designed so that, even if they fail, they will provide useful information for future actions, and monitoring and evaluation shall be emphasized so that the interaction of different elements within marine systems may be better understood" (Section 2852 (a)). Adaptive management requires learning from current experience to improve the process of achieving the goals of the MLPA over time. Success requires:

(a) Appropriately scaled, sustained institutional capacity to make legitimate choices;
(b) Possession, broad communication, and use of relevant information; and,
(c) Use of (a) and (b) to effect desired changes in policies, programs, and human behaviors intended to achieve the goals of the MLPA.

California's Marine Life Protection Act (1999) builds upon the state's prior policy efforts to protect and manage marine resources. It requires:

(a) The creation of systems of MPAs as a necessary element in achieving desired marine policy goals (complementary to, but regardless of, the effects of traditional fisheries management policies);
(b) The use of three classifications of MPAs (state marine reserve, state marine park, and state marine conservation area), with each protected area to be created with specific objectives;
(c) The development of networks of MPAs on a biogeographical region scale, designed to accomplish the complex goals of the MLPA by protecting ecosystems; and,
(d) The adaptive management of the statewide MPA network to better achieve the goals of the MLPA over time.

California, in implementing MLPA, leads efforts across the nation to develop policies, institutions, and processes for achieving adaptive management of MPAs. Consequently, few models exist to guide the design of the monitoring and evaluation framework. Application of adaptive management for the MLPA can draw upon other experiences from the past decade in riparian and coastal marine ecosystems. Importantly, assessments of adaptive management in practice reveal that its use must be customized to the specific legal, institutional, and cultural contexts in which it is applied (Panel on Adaptive Management for Resource Stewardship, Natural Research Council 2004; Gray 2000).

The literature provides some, if not complete, guidance on adaptive management. Chornesky (2005) provides useful suggestions for developing data, information structures, and information flows to inform management of ecosystems, though the report does not address the institutions within which adaptive management must occur. Thoughtful exploration of developing natural and social indicators of the performance of individual MPAs is also available (Pomeroy, Parks and Watson 2004). However, neither document describes the institutions that might support adaptive management, nor indicators appropriate for adaptive management of an MPA array or network at the scale required by the MLPA.

This approach will require the State to develop and implement a cutting-edge monitoring, evaluation, and adaptive management program. The MLPA Master Plan Framework (MPF) adopted by the California Fish and Game Commission (FGC) on August 18, 2005 describes the Monitoring and Evaluation for the MPAs. The AM&MEF compliments and expands upon the framework proposed by the MPF in two ways. First, it provides guidance on the institutions and processes for adaptive management which are not discussed in the MPF. Second, while the MPF discussion focuses on monitoring for evaluating the extent to which individual MPAs are accomplishing adopted goals and objectives (CDFG, 2005: pages 69-75). The AM&MEF describes an administrative approach at the regional scale. In it, adaptive management, monitoring, and evaluation will be implemented at multiple spatial scales, including individual MPA, MPA networks in a region, and statewide when appropriate. The Monitoring and Evaluation section of MPF should be revised in the future to reflect this change.

This document draws upon available experience from many policy areas, theories, and MPA case studies about improving decision-making and policies over time. It discusses some of the choices in developing related institutions and processes. It also advances guidance for monitoring and evaluation of ecosystems and specific MPAs that will, in turn, inform both adaptive management and day-to-day management of MPAs. More specific monitoring and evaluation plans will be required as networks or network components consisting of specific MPAs are designated (see Section 4). These plans will need to support the development of data sets over the long periods needed to detect changes in ecosystem condition with confidence. At the same time, they are likely change over time with experience and with changes in technology, scientific understanding, and the environmental and policy contexts of the state's MPA system.

1C. Adaptive Management and Monitoring in the Marine Life Protection Act

The MLPA requires adaptive management to ensure that the system of protected areas meets its stated goals [Section 2853 (c) (3)]. The Act intends the creation and management of multiple MPAs as a network to protect marine life, habitats, and ecosystems (Section 2853). The Act clearly distinguishes between individual MPAs, with each expected to meet its specified objectives, and the network of MPAs as a whole, which is expected to meet the goals of the Act [Section 2857 (c) (5)]. Individual MPA objectives will feed into regional goals and objectives and those, in turn, will feed into goals of the Act at the state level (See Appendix 1 and 2 on MLPA Goals and Central Coast Regional Goals and Objectives). The MLPA also requires that decision-making be based on the best readily available science and informed by stakeholder participation.

The definition of adaptive management used in the MLPA is consistent with contemporary understanding of this approach to improving policy performance over time, with one exception. Adaptive management seeks to address uncertainty about both (a) the natural and human systems within which policy is being implemented, and (b) the effects of the policy instruments being deployed. The MLPA does not mention uncertainty regarding human systems or policy instruments, both important to address in adaptive management. The intent of adaptive management is to learn more about both natural and human systems and policy instruments by implementing policy in ways that allow for learning and adaptation over time.

This framework for adaptive management is explicitly grounded in the legal, institutional, and cultural context of marine policies in California.

Decisions in Adaptive Management

One of the major challenges that effective implementation of adaptive management faces is identifying the types of decisions that need to be made about causation and outcomes (or ends and means). Such decisions relate to both scientific research and political questions. Lee (1999; 1993, chap. 4, modifying Thompson and Tuden, 1959) presents a theoretical matrix commonly used by analysts to help make policy decisions in situations characterized by conflict. According to Lee, adaptive management has particular relevance to policy areas where stakeholders disagree about desired policy outcomes and about the causes of problems and therefore the needed policy solutions. This is certainly the situation regarding the MLPA, where stakeholders disagree on what should be done and scientists are still trying to understand natural systems and confidently discern cause-and-effect relationships regarding the sources of ecosystem degradation and potential effects of MPAs in reversing this decline. (Russ *et. al*, 2005; Halpern & Warner, 2002; and McClanahan, 2000).

Consequently, a decision-making structure should be in place *before* an adaptive management exploration of the seascape proceeds. Since adaptive management requires a political resolution of policy choices, it is important to use scientific analyses and research to answer questions that are judged most useful to policymakers and key stakeholders.

This approach underlies the basis for the framework on how to integrate adaptive management for MLPA and each region. Designing this procedure **at the start of the program** provides an opportunity to lay out a clear, efficient, and effective process.

Monitoring

Monitoring improves our understanding of the natural and human dynamics of the marine environment and forms a critical part of effective management and scientific research. Generally three types of monitoring exist: monitoring the ecological health of the environment; monitoring to detect change; and compliance monitoring (Australia's Reef Futures website: http://www.reeffutures.org/topics/monitoring/why.cfm). Chornesky (2005) describes how monitoring plays a critical role in adaptive management because it allows managers and interested parties to:

- Evaluate the impacts of specific management choices;
- Build knowledge about the managed ecosystem and thereby improve future management decisions;
- Identify emerging threats;
- Determine the extent to which the ecological and/or socioeconomic management goals for the ecosystem are being met; and,

Monitoring programs that do a good job of servicing the link between data and decision-making can improve policy and management decisions. Consequently, the AM&MEF must include some monitoring capacity focused on synthesizing and communicating information about status, trends, and performance of individual MPAs, MPA arrays, and MPA networks at the region and statewide scales.

Clear schedules, rules, and procedures for comment, dialogue, and participation are important throughout the entire process adaptive management, as well as at planned periodic reviews or the end of a specific cycle. Objectives and criteria for measuring performance must be spelled out clearly (FAC, 2005). Representatives on the MPA Management Advisory Committee (MAC) will need to explicitly consider values as well as scientific analyses in establishing goals, objectives, and priorities within the context of the MLPA. Scientific working groups, analyses, and technical reviews will be needed to identify the best indicators to measure progress towards these goals and objectives and the feasibility of setting a benchmark or threshold that would trigger a change in policy or management.

2. MLPA Adaptive Management Process for Ecosystem-based Management

This section outlines adaptive management for ecosystem-based management. It begins by defining the boundaries determined by science and that will be used administratively, then discusses a process, structure, and roles of institutions.

2A. Adaptive Management at the Administrative and Regional Level

Adaptive management aims to improve and change policy and management practices based upon monitoring and evaluation results. The AM&MEF is designed to consider ecosystem patterns and processes. It is grounded in science and defines goals on the basis of ecological, rather than political, boundaries and addresses ecological, social, and economic goals. The development and implementation of ecosystem management are critical in ensuring sustainability in California's coastal marine systems.

As a practical matter, adaptive management under MLPA will require defining both boundaries of natural systems, such as ecosystems, networks, and biogeographic regions and administrative units created by the MLPA, such as MPAs, arrays or regions of MPAs. Clarifying definitions is key, yet many basic terms are in flux. For example, various observers define the boundaries of natural systems differently, as seen in the discussions among members of the MLPA Master Plan Science Advisory Team about whether two, three, or more biogeographic regions exist in California and whether ecosystems may be in individual MPAs and/or networks of MPAs. The boundaries of the administrative units defined by policy choices are often hotly contested and change over time.

Other practical challenges arise in selecting the appropriate operational scale for adaptive management – e.g. should it be a region? – and for designing institutional structures and administrative processes. The implementing entities will need to have capacity and incentives to collect, manage, and analyze information and to make and implement adaptive management decisions at these scales. Moreover, they must be capable of making different kinds of decisions over different time periods (e.g., years to decades for MPA designations versus months to years for enforcement, education, and data collection).

Adaptive management under the MLPA should occur at several different levels – the individual MPA, MPA arrays / networks of MPAs across a region, and networks of MPAs across the state to ensure effective ecosystem-based management. However, networks of MPAs across a region should serve as the primary administrative scale for adaptive management. This administrative level, the network of MPAs across a region, will look at data and analyses from multiple levels to make recommendations to the California Department of Fish and Game (DFG) forwarding to the FGC for consideration and possible action. The MLPA Blue Ribbon Task Force adopted a recommendation to endorse the concept of two biogeographical regions within state waters, divided at Point Conception. The MLPA Master Plan Scientific Advisory Team (SAT) agreed that this was the strongest biogeographical divide within California, but discussed other biogeographical regional divides, with most judgments supporting identification of three to five bioregions in state marine environments.

Adopting the biogeographical region concept for adaptive management has many advantages:

- It corresponds to a significant unit of scale used by scientists (and underlying natural phenomenon);
- It matches the legal requirements of networks of MPAs within biogeographical regions;
- It results in a limited number of areas for information aggregation and decision-making;
- It is consistent with the use of the southern region outlined in the California Nearshore Fisheries Management Plan corresponding with a committee structure and process. The northern region of the California Nearshore Fisheries Management Plan is further divided into three regions; and,
- It can incorporate the recently-established MPAs at the northern Channel Islands into the southern bioregion network during the regional MLPA process which considers the southern California mainland and the other offshore islands. The designations of those MPAs may be changed in the course of developing a network of MPAs for the southern California bioregion.

The biogeographical region concept has a few disadvantages:

- It encompasses significant distances, which can encourage data-driven discussion removed from "ground truthing" in actual experiences;
- Aggregation at this scale could obscure smaller-scale phenomena that are ecologically important or significant to stakeholders and other interested parties; and,
- The difficulty, costs, and time required to do analyses at this scale will be greater.

The MLPA Science Advisory Team can recommend a change in the number of regions to the DFG and then this recommendation can be presented to the FGC for adoption. Furthermore the identified four regions in the Nearshore Fishery Management Plan are discretionary, not statutory, and could be modified.

2B. Adaptive Management Process

The literature and experience in MPA and fisheries monitoring emphasize the strategic importance of involving policymakers and stakeholders early on in shaping monitoring and adaptive management priorities (See Appendix 3: Case Studies of Existing MPAs Monitoring & Evaluation Plans and Pomeroy 2004; NRC 1990, 2001; FAC, 2005). In fact, the authors of the 2001 National Academy of Science report argued that millions of dollars in monitoring proved of little use partly because the questions were framed by scientists operating apart from the users of the information (NRC, 2001).

Effective stewardship will need effective communication among all interested and affected policymakers and stakeholders, as well as the general public. Policymakers, stakeholders, and scientists should engage in conversations about their values and the relative role of these

values to monitoring, evaluation and adaptive management in the context of the MLPA goals and requirements. This conversation should take place at an early stage in the development of the regional adaptive management and monitoring and evaluation plan after selection of the preferred alternative. Note, however, that there will still be considerable work for scientists and specialists to do in terms of identifying questions, stating assumptions, and constructing models. The more technical aspects of the work may not be appropriate for extensive participation by policymakers and stakeholders. However, whenever possible, local knowledge and co-management strategies need to be incorporated into the planning process (FAC, 2005).

A committee structure is the most common practice for including stakeholders in adaptive management. The more transparent and forthright the process is, the more effective it will be in gaining stakeholder support, and developing a sense of shared stewardship.

Institutions and Work Flows for Adaptive Management

The MLPA clearly requires decision-making informed by science, details a particular form of participation for a team of scientists [Section 2855 (2), Section 2855 (3)], and calls for a stakeholder involvement [Section 2853 (c)(5), Section 2855 (c), Section 2857 (a)], and public participation [Section 2853 (c)(4), Section 2854)]. Formal policy making regarding MPA boundaries and regulations, including any creation or modification of individual MPAs, is within the authority of and requires action by the FGC (Sections 2859, 2860 and 2861), and in some cases the Park and Recreation Commission (Marine Managed Areas Improvement Act 2000). Indeed, the MLPA clearly requires after adoption of the master plan for all MPAs, the FGC shall "at least every three years, receive, consider, and promptly act upon petitions from the DFG or any other interested party, to add, delete, or modify MPAs, favoring those petitions that are compatible with the goals and guidelines of this chapter" [Section 2861 (a)].

For these reasons, adaptive management must include five institutional structures:

1) FGC, as formal policymaker and Park and Recreation Commission for its role in creation and modification of State Marine Parks (SMPs);
2) A body of scientific advisors;
3) A process for stakeholder involvement;
4) Opportunities for public participation; and,
5) DFG and California Resource Agency[2].

The membership, powers, and operating procedures of the FGC can be changed only by statute, but more flexibility exists in how the other four elements are structured and operate. Importantly, these four elements may be complemented by other institutions, exemplified by the MLPA Blue Ribbon Task Force (BRTF) created by the memorandum of understanding

[2] The California Resource Agency acts as the liaison between departments and the Governor.

(MOU) foundation of the MLPA Initiative. While the FGC operates at the scale of the State of California, the institutions to support adaptive management can be designed at other scales.

Thus the main choices in designing institutions and work flows for adaptive management of the MLPA in California focus on these areas:

- Geographical scale;
- Structures for scientific advice, stakeholder involvement, and public participation;
- Possible additional institutions (such as the MLPA Blue Ribbon Task Force); and,
- Work flow (which defines the relationships among actors).

Structures for Scientific Advice, Stakeholder Involvement, and Public Participation

Two approaches have been taken to develop structures of bodies/groups for scientific advice and stakeholder involvement in MPA policy making in California, and at least one other model exists elsewhere (see Appendix 3 Case Studies on Existing MPA Monitoring and Evaluation). Public involvement is often expected to occur through formal public meetings (such as those of the FGC). Three approaches to structures for scientific advice and stakeholder involvement are:

1) Scientists and stakeholders in one advisory structure (model of the Channel Islands and the Monterey Bay National Marine Sanctuaries (MBNMS) and other National Oceanic and Atmospheric Administration (NOAA) sanctuaries);
2) Scientists and stakeholders in separate groups, providing input to a seasoned group of policymakers (the MLPA Initiative model with Blue Ribbon Task Force, Science Advisory Team (SAT), and Central Coast Regional Stakeholder Group (CCRSG)), as well as the Fishery Management Council model with a main council supported by a variety of advisory bodies including a Scientific and Statistical Committee); and,
3) A stakeholder group as the key body to which scientists and technical staff provide support (The Grand Canyon Ecosystem Adaptive Management Program, 1999).

The structure most appropriate for the MLPA is structure (1) above because effective adaptive management occurs over long time periods and will benefit from participation by stakeholders and scientists who either have or can gain deep familiarity with the issues and the implications of their choices. Note, however, that membership in this group will need to cycle periodically, to avoid the development of entrenched positions and decision-making driven by the individual personalities of participants, and to refresh the base of knowledge and experience that informs the committee's deliberations.

The MLPA Initiative process has been characterized by extensive opportunities for public participation, including web posting of draft work products for review and comment, open meetings (most with public comment periods), webcasting and/or web-archiving of all meetings of the BRTF, CCRSG, and SAT, creation of a statewide interest group (consisting of

stakeholder representatives) to design and monitor public participation, and extensive staff communication with individuals and groups.

The likely list of participants in an MPA advisory body is likely to overlap with, although it will not be identical to, the lists for bodies dealing with fisheries management policy making, such as the Pacific Fishery Management Council and of the proposed Nearshore Fishery Management Plan Committee for the State of California (for a full description see Appendix 4 and 5).

RECOMMENDATION

This framework recommends the creation of an advisory body to DFG consisting of both stakeholders and scientists to guide adaptive management under the MLPA. This group would be named the "MPA Management Advisory Committee for _____ Biogeographical Region." Appointments to the body would be made by the DFG Director.

The roles of this group would include:

1) Identifying the questions, in collaboration with Institute staff, to be addressed by science to support adaptive management, including questions relevant to natural systems, human systems, and management actions pursuant to approved networks of MPA.
2) Reviewing the design of monitoring and evaluation efforts to address the identified questions.
3) On a regularly scheduled basis established when the network of MPAs is created, but no less frequently than every five years (although it may take longer than five years to see significant changes), complete a systematic review of performance of the network of MPAs within each biogeographical region and a review of the performance of individual MPAs for (a) their contribution to the network, and (b) against the objectives specified for that MPA.
5) Based on the judgments reached in these reviews, the MPA Management Advisory Committee (MAC) would develop recommendations in one or more of the following areas: (a) changes in management operations of individual MPAs within their current designation, such as a shift in enforcement or education activities, (b) changes in the boundaries or regulations of individual MPAs intended to better achieve network goals or the objectives of the individual MPA, (c) the abolition of an existing MPA, (d) creation of a new MPA, or (e) change in the goals being pursued with a network of MPAs.

The MACs will need to meet regularly to establish effective working relationships and to master their complex roles. Furthermore, all regional MACs should meet annually for statewide discussions about lessons learned across the state and to ensure consistency of process and approach. This can be re-assessed after a year to determine if more or fewer meetings are necessary.

The work load of MACs will vary. It is likely to be high during the initial phase of identifying researchable questions and approving monitoring and evaluation programs, then less during monitoring of implementation, and increasing again when considering possible changes to MPAs, goals, or objectives under the regularly scheduled adaptive management cycle. Given

this variation in work load, it is reasonable to expect the need to meet will vary also, probably requiring two meetings per year in the periods of lighter work load and four meetings per year during heavier work loads. To offset the large workload members may receive a stipend.

As the geographical range encompassed by MACs will be large, the committees may consider establishing sub regional committees to assist the MACs. These groups would probably be busiest in the adaptive management cycle.

DFG currently coordinates or recently coordinated (some are no longer active) a total of 15 advisory committees (see Appendix 6 for the complete list with description of composition and function). In 2006 the DFG may create the Nearshore Advisory Committees (NAC), whose purpose overlaps with some of the MLPA goals. Regional committees may be developed to serve the functions of both the MPA Management Advisory Committees and the NAC for three reasons[3]. First, the DFG has limited resources, and managing all of these committees takes time and money. Second, the NACs have not yet been created and will advise on some of the same issues as those proposed by MLPA MACs. Finally, the NACs would be established within the timeline that works for the MLPA. The NAC and MAC will have equal representation and MAC members will have knowledge and interests in non-fishery issues such as management, recreation, aquaculture, climate change, monitoring and evaluation, and other issues relevant to the MLPA to ensure balance in the group. However, combining the two committees will be reviewed in the future to determine whether or it is effective and the committees may become independent if deemed necessary.

Roles in the MLPA Adaptive Management Processes

For adaptive management to succeed, sufficient capacity and incentives to undertake this approach must be present for the implementing organizations. The risks of lack of capacity and incentives are well illustrated in the Northern Coast Range Adaptive Management Area adopted in 1994, encompassing 113,000 hectares of federal land in the Coast Range of Oregon (Gray, 2000). Gray (2000: 16-17) identifies specific factors that contributed to the lack of effective adaptive management in Oregon's Coast Range region:

1) Uncertainty and conflict over the scale ("landscape," watershed, whole area) at which adaptive management decisions were to be made.
2) Tendency to prescribe solutions rather than identifying uncertainties and opportunities to pursue different alternatives as a way to learn.
3) Declining financial resources to key implementing organizations.
4) Lack of flexibility in organizational programs.
5) Tendency to limit choices considered to avoid prior battles.
6) No one (a single organization or profession) "owned" adaptive management.
7) No effective way was found to manage the inherent complexity of hundreds of species, ecosystem functions, and multiple spatial and temporal scales.

[3] Issues dealing with offshore MPAs will not be discussed by the NAC.

Significantly, with the possible exception of local risks to endangered species, all these suggestions are standard management prescriptions for achieving any long-term goal. Without appropriate project design, formal interagency commitments, job descriptions, and rewards, no policy will succeed. As Gray (2000: 18) suggests, institutionalizing adaptive management as a component of job descriptions, project designs, reporting, training, etc., is extremely important.

Chornesky (2005: 9-14) draws related relevant lessons about the kinds of information systems and flows that can best support adaptive ecosystem management from a review of case studies. Her lessons about monitoring are:

1) Create value and impact by directly linking monitoring to resource decision-making and ensuring that data are highly credible.
2) Ensure longevity by formalizing accountability of the participants and by developing sustained funding streams.
3) Make things happen with dedicated capacity and institutional autonomy.
4) Start out with an integrated information system.
5) Maximize data access, analysis, and reporting to support public processes.
6) Plan for change.

Multiple actors – public, private, and non profit – will likely be involved in adaptive management and monitoring and evaluation. But to ensure success, it is critical to give full support to the State of California's two responsible agencies: the DFG and the FGC. The DFG is the lead agency in implementing the MLPA. Currently, it only has a few individuals deeply knowledgeable about the MLPA, and budgeted funds generally have ebbed and flowed over the past decade. On a positive note, the DFG has seen substantial growth with terrestrial habitat conservation policies and programs – experience which is likely to be relevant to MLPA implementation. Still, the DFG may need to allocate more personnel to and focus on the adaptive management process related to MPAs. The FGC, in turn, is responsible for formal policy making, including any changes made through adaptive management process. It relies on the DFG and public input for information.

The challenge of orchestrating the cooperation of the multiple organizations represented on these committees and on the implementation of the AM&MEF can be accomplished through the creation of new, staffed, independent, operating unit (referred to in the Executive Summary as the Institute) with the "**singular purpose and dedicated capacity** to allow the partnership to move forward" by coordinating monitoring and research, managing data, catalyzing research and development of new monitoring and analytical methods, translating results for different target audiences, and adaptive management. Various examples exist of such organizations, such as the Southern California Coastal Water Research Project Authority. In this way, the operating unit can ensure the operational relationships among monitoring, research, and the science needs of decision-making as well as deliver information about ecosystem condition and performance over the sustained time frame that will be essential for adaptive management. The Long-Term Funding Recommendations to Resources Secretary Chrisman

approved by the Blue Ribbon Task Force include a recommendation to create a "California Marine Monitoring and Evaluation Institute" (referred to as the Institute) as a structure through which multiple parties can collaborate. (Recommendation 5.2)

Table 1 identifies roles describes the process in adaptive management under the MLPA that are recommended in this framework. It is important to try and streamline consultative and reporting functions as appropriate. The institutional choices follow the recommendations made in the sections above.

Table 1: Institutional Roles in MLPA Adaptive Management Processes

Entity	Identify science questions re. adaptive management	Design monitoring and evaluation program	Implement network of MPAs and monitoring and evaluation program	Monitor MLPA implementation and monitoring and evaluation program	Adaptive management review and recommendations
FGC: The FGC has authority to establish, modify, or delete state marine reserves and state marine conservation areas. The FGC may establish fishing regulations for state marine parks, but must have the concurrence of the Park and Recreation Commission (see below) to establish, modify or delete a state marine park.	D	D	O	O	D
DFG: The DFG has management authority over living marine resources within state waters (generally between 0 and 3 nautical miles from shore or around offshore islands, with a few exceptions such as Monterey Bay) as well as authority to regulate fisheries that deliver catch to California ports. Thus, DFG has some authority beyond state waters and often enforces regulations outside the 3 nautical mile line. DFG enforces laws established by the California Legislature and regulations established by the FGC.	T	T	M[4]	A	T
MAC: Regional bodies of scientists and stakeholders appointed by the DFG Director to review and approve adaptive management of MPA networks. They make recommendations to the DFG	R	R	NR	R	R
The Institute: Statewide entity whose staff will support implementation of AM&MEF. The steering committee will be appointed by the DFG. It will	A	M	M[5]	M	M

[4] Implement network of MPAs

report to the DFG and work in coordination with the MACs.					
External Researchers/Experts: Institute will contract out aspects of work that require scientific input and expertise.	A	A	NR	A	A
Peer Reviewers: Independent scientific experts to review and assess implementation of adaptive management, monitoring and evaluation design and results.	A	A	NR	NR	A

Key: A=Analyze and provide recommendation and /or report, D=Authoritative decision, M=Operational management, R=Recommend (initial), T=Transmit, with recommendation, O=Oversight, N=No administrative, management, or decision-making role

[5] Implement monitoring and evaluation program

3. Statewide Oversight and Management for AM&MEF Implementation

There are many ways to set up the infrastructure for monitoring, evaluation, and adaptive management implementation. However, it is a challenge to orchestrate and sustain the cooperation of the multiple organizations involved in the MLPA. Funding and priorities of participating organizations change and new responsibilities can compete for staff time and energy (Chornesky, 2005). One way to avoid this issue is to create a new organization, the Institute, and identity that can push the partnership(s) forward (discussed in previous section).

A predictable funding stream and dedicated capacity and leadership, which will come from the creation of a new operating unit, are vital for implementing major portions of the monitoring plan and for promoting sustained implementation. Creating mechanisms of accountability for partners and participants as well as long-term sustainable financing will help ensure the long-term success of the MLPA AM&MEF. This formalization could be accomplished by: 1) multiple agencies or organizations may enter into a statutory or voluntary agreement, and/or 2) partner institutions or individual scientists may receive grants or contracts for agreed upon work. The structure established to coordinate monitoring, evaluation, and adaptive management must provide transparency of the AM&MEF adopted process. South Bay Salt Ponds Restoration and Southern California Coastal Water Research Project Authority are just two examples of organizations that were created with a partnership mandate and intend to create sustained funding streams.

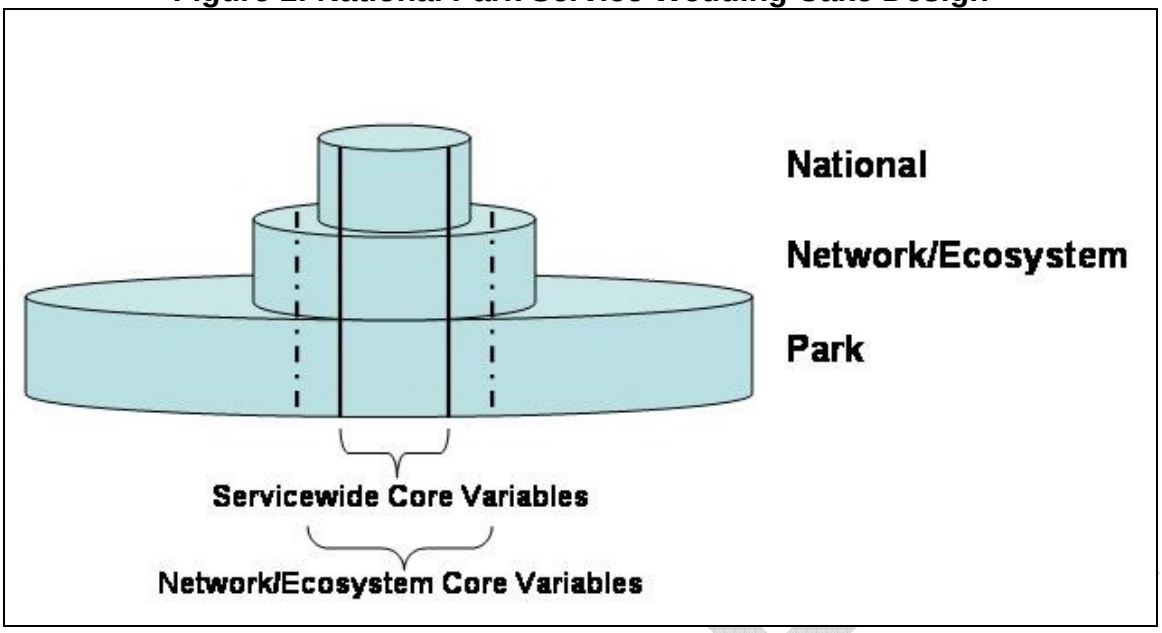
3A. Indicators, Measurements of Progress, and Questions

Monitoring Indicators

The indicators that will be selected to monitor throughout the MPA statewide network may follow the “wedding cake design” used by the National Park Service and adapted from the USDA Forest Service. Indicators will be needed at three levels (see figure 1). At the “park level” (in the MPA statewide network the equivalent is the individual MPA or local MPA network), site specific data will be needed by resource managers and other stakeholders to make management decisions. The “network/ecosystem level” (in the MPA statewide network the equivalent is the region) will also have a set of indicators that are monitored in a standardized way to allow for larger area comparisons, to assess system properties best addressed at this scale, and to synthesize the data. At the “national level” (in the MPA statewide network the equivalent is the statewide), again a set of indicators will be monitored that are most relevant for evaluating policies at this scale. For the MPA statewide network, a select group of MPAs can be monitored for the AM&MEF (Section 2853 (c)(3) of the MLPA). However, developing a network monitoring program with control areas outside of MPAs will require a large investment in planning and design to guarantee it meets the requirements of the MLPA and objectives of each MPA. It is crucial to solicit stakeholders’ participation in deciding which indicators to monitor at all levels so that indicators reflect key values of interested parties and the public.

Once the *Monitoring and Evaluation Report* is developed, a core list of indicators will be established for the state and for each region. This list will be guided by the statewide goals, and the regional goals and objectives. The list of indicators will be drafted by the Institute staff with scientific, MAC, and policymaker input. Individual MPAs will have a menu of indicators, but not all indicators will be measured in each MPA. As these data are collected, results will be analyzed by the Institute staff and cooperators to determine status and relative change. Further, data gathering activities need to be coupled with an effort to learn more about the system's properties over time – and therefore improve our ability to say with any certainty whether the MPA designation is yielding the desired result. Review of these results will be used to evaluate whether or not the MLPA is effective in achieving the goals and objectives at both the region and state level.

Figure 1: National Park Service Wedding Cake Design



Source: http://science.nature.nps.gov/im/monitor/3-PhaseApproach.htm [National Park Service Inventory and Monitoring website]

Although the topic of indicators and measuring performance is presently under discussion between scientists and managers, several ongoing efforts are underway that could help inform the choices ahead in designing California's MPA monitoring system. Currently, NOAA's MPA Center is hosting workshops with experts from around the United States to recommend a suite of indicators for the National MPA Network on Marine Natural Heritage. NOAA's working group now has a comprehensive list of indicators for the natural sciences that it will narrow down to seven. Syms and Carr (2001) propose a set of parameters for individual and networked conservation MPAs, with parameters at the species, community, and ecosystem level (see Appendix 7).

Similarly, the process of translating objectives into questions has not been done for many MPAs. However, experience in places like the Channel Islands, Great Barrier Reef Marine Park Authority (GBRMPA), and the Florida Keys National Marine Sanctuary (FKNMS) can provide useful insights into potential methods for developing strategic science agendas.

The Channel Islands case study provides some experience with planning processes as well as lessons on how to improve that process. The DFG translated the MPA objectives for the Channel Islands MPA network into scientific questions and potential monitoring activities (DFG, 2004). Scientists developed a list of monitoring questions that reflected their interests and major goals and objectives. Stakeholder and scientist participation in workshops resulted in various documents on socioeconomic and biological monitoring (NOAA, 2003; DFG, 2004). In the end, however, this process did not clearly document the links among MPA goals, objectives, and monitoring. Nor did it establish an overall monitoring structure that could act as a clearinghouse for monitoring information, deliver monitoring results in a form accessible to

interested audiences, or provide for permanent data archiving, access, and data quality control.

Since the Channel Islands MPAs were created outside of the MLPA process, they used a different set of goals than those in the MLPA, although some similarities exist. Since the Channel Islands MPAs ultimately will become part of the southern California region MPA network, the challenge will be to integrate their goals and objectives with those established under the MLPA regional implementation process. Some modification may occur. Similarly, the management plan and monitoring and evaluation plan developed for the network of MPAs created for the southern California region should incorporate the Channel Islands MPAs, which also may require modification of existing management and monitoring and evaluation plans.

GBRMPA recently developed a detailed list of priority research questions for park management (GBRMPA 2005). The final 21 priority questions, out of an initial list of 270 research needs identified for park management, were deemed to be of critical importance, with answers needed within one to three years. This prioritization was accomplished through extensive consultation with staff, the scientific community, and GBRMPA's Tourism and Recreation Reef Advisory Committee. This process took two years and involved extensive scientific and stakeholder input. Although such an extended timeline will not work for the MLPA AM&MEF, what can be learned from this process is that involving various stakeholders and policymakers at this stage is important in creating support for and trust in management and policy decisions.

Indicators can be selected in different ways. Conceptual modeling has been widely adapted across the National Park Service as a tool in ecosystem management projects. Conceptual models help formalize and articulate assumptions about ecosystem structure and function and the anticipated responses to management interventions. Florida Keys National Marine Sanctuary (FKNMS) recently designed a conceptual model to determine which parameters to monitor (NOAA, 2005; FKNMS, 2003; NOAA, 1998). A conceptual model helped determine the relative importance of known functions of the major biological components of the ecosystem and helped identify critical parameters to monitor in order to detect changes in important attributes of the ecosystem.

Successfully applying lessons from the examples above to the Central Coast and other regions in California will involve policymakers, scientists, and stakeholders in the translation of goals and objectives into questions that may be answered through monitoring. Priorities must be set according to both values which define the shared vision of success for the future and scientific merit in evaluating progress towards this vision. While indicators should be simple and understood by all stakeholders, they need to be selected through a scientific process. It is also crucial to establish a clear statement of the desired outcome, while simultaneously considering variability and the multiple interacting factors which affect ecosystem condition as well as the long-time scale required for assessing ecosystem response (NFCC, 2004; FAC 2005).

Indicator Issues

There are many issues to consider when selecting indicators and the most relevant experience in marine systems comes from fishery applications which may not satisfy the full set of needs for evaluating MPA ecosystem condition.

The NOAA Working Group Natural Heritage identified several variables to consider when selecting indicators:

- Sensitivity (statistical power): ability of data to identify an effect or change
- Can a target be determined
- Can a threshold be determined
- Timeline: length of time for a metric to respond to a management action
- Ease of collecting data
- Cost to acquire data
- Response rate
- Variance: natural variability
- Translatable to the public

Other issues include, for example, considering fisheries independent and fisheries dependent. There are a number of ways in which these data can be biased because the purpose of fishing is to catch fish rather than to measure objectively fish stocks (CDFG, 2005). Further, metrics designed to reveal fishery dynamics may not address issues of ecosystem condition. The Institute staff, collaborating scientists, and scientists on the MAC will need to address such issues when selecting indicators.

Benchmarks or Relative Change

Some debate presently centers on the feasibility of developing explicit benchmarks for evaluating progress towards an MPA objective. This issue will need to be considered by the MAC in their consideration of monitoring designs proposed by the Institute staff.

When significant uncertainty exists regarding how ecosystems are structured and function, scientists may be reluctant or unable to make firm predictions about the system's response to management interventions. In such cases, scientists may rely upon measures of relative change in protected areas. This is the approach taken in the Channel Islands MPA monitoring plan, which does not use absolute benchmarks (e.g. x% kelp canopy cover or some specific value of a species diversity index). Instead, it defines performance relative to unprotected areas or other suitable reference locations (CDFG 2004). According to the present monitoring plan, the Channel Islands MPA network will be considered as performing satisfactorily, for example, if the biological trends within MPAs approach given estimates of potential change more rapidly than areas outside of the MPA.

In measuring relative performance, various options exist for selecting the performance metrics or benchmarks. The appropriate option may depend on the indicator under consideration. As

the Channel Islands example above illustrates, one possible way to establish relative performance metrics entails asking whether there is a statistically significant difference in some quantity or amount (e.g. 20% greater) in some quantity when measured in the MPA vs. a reference site (or a Year 0) in some specified time interval. An alternative approach is to develop conceptual or quantitative models (such as the FKNMS example) that can guide predictions about anticipated responses of the system to MPA designation, and therefore aid in developing qualitative or quantitative benchmarks of progress.

The National Fisheries Conservation Center (NFCC) report, in addressing the challenge of long-time horizons for detecting changes in marine MPAs, suggests that monitoring "should focus on interim benchmarks of progress that reflect an underlying mechanistic understanding about how the MPA is expected to produce its desired effect(s)" (NFCC 2004) – an approach that is more consistent with the development of conceptual models. Syms and Carr propose determining targets, specified levels, or directions for each of these parameters or response variable, as well as assessing whether or not there are limits or acceptable deviations from specific targets. Institute staff, along with scientific feedback from the scientists, should propose to the MAC what is appropriate for each variable monitored.

Recommendations

For the development of each *Regional Monitoring, Evaluation, and Adaptive Management Implementation Plan,* the Institute staff with scientific input, feedback and review from MAC and policymakers should develop the questions and indicators in the context of the goals and requirements of the Act.

Where appropriate, the Institute staff should collaborate with and learn from others who are developing indicators, such as NOAA. In addition, a science-based process with expert input and external peer review will be necessary to design the most robust and strategic set of indicators for determining progress towards an objective. Furthermore, because certain of the indicators and methods must be consistent across the state, it will be critical for the *Monitoring and Evaluation Report* to be regularly reviewed and updated as more regions and MPAs join the state network and scientific knowledge improves.

3B. Science Design and Methods

The design of the monitoring, evaluation, and adaptive management program for network(s) of MPAs or components of a network, of this size is complex and confronts several issues discussed below. Addressing these issues will require a deliberate design process followed by rigorous external peer review prior to implementation.

There are many ways to set up the design for collecting biological, physical, and socio-economic data for the AM&MEF. Four main approaches are:

1) A Statewide Survey: Statewide monitoring randomly or purposely stratified could provide robust results since it would eliminate the challenge of finding appropriate

reference sites. However, a statewide survey could involve considerably more resources than monitoring only localized areas.

2) Within MPAs: This monitoring would provide information on the state of protected resources and ecosystems.
3) Inside MPAs vs. Outside MPAs: This approach would compare and contrast conditions over time. Inferences could be made on differences among MPAs. For this approach to be valid, it requires having control sites with comparable habitat as well as with fishing activities.
4) Multiple MPAs and Controls: This approach would allow inferences on general MPA effects, influence of MPA environmental design features, and predict effectiveness. Pairs of MPAs are selected inside and outside MPAs across a range.

In addition to location of monitoring, the timing of monitoring is also an important factor. Below are the two main approaches:

1) After-Control-Impact (ACI): If it is not possible to collect data prior to MPA establishment or at implementation, it can be collected intensively during the first year, as was done in the Channel Islands to supplement the 20-year baseline of non-MPA specific data collected prior to MPA establishment. Comparing data from inside and outside the MPAs can provide insight into how the establishment of the MPAs has affected the trajectories, trends and patterns of two systems over time and how the sites are changing in predicted ways.
2) The Before-After-Control-Impact (BACI): BACI can provide information on the effectiveness of MPAs at protecting species targeted for exploitation (Syms and Carr, 2001). BACI is more common than IVRS (see below) and requires that reference sites (to which MPAs will be compared) be as similar as possible to MPAs. Although these sites are often challenging to find, BACI is based on the model that temporal differences in sites are attributable to MPA effects and therefore can make site specific statements about MPA effectiveness (Syms and Carr, 2001). There is a rich literature on BACI designs (Steward-Oaten and Murdoch, 1986; Stewart-Oaten and Bence, 2001; Schroeter *et. al*., 2001).
    a. The Impact vs. Reference Site (IVRS): This approach uses before and after data for MPA comparisons. This approach assumes that the MPA and non-MPA sampled areas are independent, formally randomized experimental replicates, and therefore sites are randomly assigned to controls or MPAs. This approach requires that sites (either in MPAs or control areas) are independent (do not affect each other), but this condition of independence is often difficult in reality to maintain (Syms and Carr, 2001).

Based upon the timing of MLPA implementation and the MPA site selections, different approaches may work for different indicators and areas. BACI and IVRS approaches will most likely be effective in the Central Coast, where locations of MPAs known, and established in the near future.

A rich literature on research design can be reviewed once the questions and indicators are selected. It is recommended that the Institute Staff in consultation with scientists on the MAC and other experts devise the general nature of the sampling design, especially in view of the availability of pre-establishment monitoring data relevant to selected indicators. Finally, although the MLPA (Section 2853 (c)(3)) and scientists may not require monitoring in every site, some form of periodic rapid assessment may be needed at sites that are not routinely monitored to ensure sound adaptive management and for policy and public education purposes.

Control Sites and Replicates

A number of additional challenges are associated with ensuring that sufficient data are collected to satisfy the primary purpose of a monitoring program. The primary purpose of collecting data inside and outside of MPAs is to make statements about differences between these two types of areas as related to the increased protection afforded by the MPA. Willis et al. (2003) critically evaluated experimental designs employed in published studies related specifically to reserves (one type of MPA) and identified problems with replication and lack of control sites:

- Only one site sampled inside and outside a reserve, or no control sites sampled at all (insufficient sample replication)
- All control sites located only at one end of the reserve (spatial confounding)
- Surveys only done at one time (lack of temporal replication)
- Not enough reserves sampled
- Reserves are often sited to include special or unique features so finding controls is difficult (Willis et al. 2003).

These problems can affect the ability to determine whether or not differences among control sites and MPAs exist. Willis et al. acknowledged that some of these problems are unavoidable due to the nature of the reserve system. However, while identifying a perfect set of controls and replicate sites may be impossible, ideally, control sites should be located in order to balance competing priorities regarding proximity to the protected areas to which they will be compared. Control sites should not be so close to the protected area that their biological features are enhanced because of the protected area. However, the sites should not be so far away that the conditions and habitats do not match (Gell and Roberts, 2003). It is recommended that the Institute staff develop criteria for control sites and replicates and the list of locations in consultation with the scientists on the MAC. The Institute will need sufficient planning time and resources to implement rigorous survey designs, intensive baseline data collection, and data management systems.

Spatial and Temporal Considerations of Research Design

In order to understand the trends and patterns of indicators being measured, scientists must understand how spatial and temporal variability can complicate data collection and analyses.

Knowledge about trends and patterns of the indicator being measured should be incorporated into the monitoring design. For example, behavioral patterns, migration, and mobility of species can change annually or seasonally. Syms and Carr (2001) explain that some parameters may be restricted to within the boundary of the MPA, such as increased larval production, and others may be manifested over a greater spatial expanse, such as larval dispersal to, and replenishment of fish populations outside of, an MPA. Furthermore, natural spatial variability can confound control effects if the parameter of interest is not similar prior to the effect that is being measured (Osenberg and Schmitt, 1996). When selecting controls, pairs of geographically adjacent sites can minimize this spatial variation (Tissot and Hallacher, 2003). When conducting meta-data analysis, variability among the sizes of MPAs or reserves may need to be taken into account. Furthermore, confounding factors may interfere with large data sets.

Conceptual models of the ecosystem that reveal relevant temporal and spatial patterns can aid in ensuring effective monitoring designs at multiple spatial scales. Ideally, data or at least a conceptual model of relevant temporal trends and patterns of indicators should exist before determining how to monitor. Syms and Carr give the example that some parameters may respond quickly in some species after MPA establishment, such as change in population size structure of a fast growing species within a MPA, while others may take many years, such as the increased recruitment of a slow-growing species into a catchable stock outside the MPA. Different indicators need to be monitored at different time intervals. For example:

- Data measuring the recovery, measured as the proportion of the total MPA area or focal species population (abundance, biomass, or % of total pop.) that has experienced or "been restored" to assumed original target levels of either community composition, natural conditions, or viable populations levels and stock integrity, could be measured between every two to five years (Pomeroy *et. al.*, 2004).
- Survey data measuring the "perception of seafood availability" should be asked for the same time period every (season, month) of every year (Pomeroy *et. al.*, 2004).
- Survey data measuring the "local understanding" of the MPA rules and regulations can be collected at the start of the project and every year after (Pomeroy *et. al.*, 2004).

Most marine management organizations recommend indefinite monitoring (Pomeroy *et. al.*, 2004). Nevertheless, Gerber et al. developed a model to answer the question, "How long should we monitor the recovery of an over-fished stock to determine the fraction of that stock to reserve?" and concluded that monitoring was maximized between three and seven years, with a discounting rate of 1%, depending on the precision of monitoring (Gerber *et. al.*, 2005). However, this model is not applicable to MPA monitoring because of its simplified structure (e.g. covering a single species fishery) and assumptions (e.g., it did not take into account interactions between species). In comparison, a goal of MPA designation is to sustain ecosystem health and benefits in perpetuity – a challenge likely to require continued attention in a world where the environment and human uses and values are constantly changing. Table 2 illustrates the tasks and related time frames at which monitoring may need to occur. Following the NPS wedding cake (figure 1), at the individual MPA there may be more

indicators and they may be collected more frequently, whereas select sites and indicators at region or state scale may take place less frequently. The relative frequency of data analysis and reporting may similarly vary. Review and adaptive management will occur less frequently as the scale increases.

Institute staff in consultation with experts and MAC scientists should design data collection schemes that incorporate considerations of indicator sensitivity and spatial and temporal variability. Furthermore, where possible intensive data collection of all, or the most critical, indicators at all sites before MPA establishment is recommended. Where pre-designation data collections are not possible, surveys should be conducted at year 1 and then again in the future at intervals determined by indicator sensitivity. Mechanism that confer flexibility will also be needed so that monitoring activities can be rapidly mobilized in response to emerging threats (e.g., invasive species, oil spills, and the like) or unusual environmental perturbations.

Table 2: Illustrative Table of Scale and Temporal Comparison for Adaptive Management and Operations

Task	Individual MPA	Region	Statewide
Data Collection[6]	Seasonal or Annual	Annual - Biological Annual - Social	Multi-year - Biological Annual - Social
Data Review	Annual	Multi-year	Multi-year to Decadal
Operational Changes	Seasonal	Annual	Annual
Adaptive Management	Decadal - Biological Annual - Social	Decadal - Biological Multi-year - Social	Multi-decade - Biological Multi-year - Social

As determined by the overall monitoring design, In between intensive data collection years, a smaller subset of sites may need to be sampled.

Statewide Universal Methods and Data Management Requirements

All grantees, subcontractors, or partners awarded funds to collect data will be required to use methods explained in detail in the *Monitoring and Evaluation Report* and other protocols adopted by the Institute and to deliver data to the state MPA monitoring entity in a format compatible for data management. Further, scientists receiving permits for research activities at the state's MPAs or conducting research using the monitoring data will be required to share their findings and products, and where appropriate their data, with the state MPA monitoring entity for the latter's use in evaluation of MPA condition, information synthesis, reporting, and communication.

[6] Data collection should occur when most appropriate for the variable being collected. This table is designed for illustrative purposes.